

Discovery of a new torque reversal of the accreting X-ray pulsar 4U 1626-67 by Fermi/GBM

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on behalf of the GBM pulsar project

(1) FECYT, (2) NSSTC, (3) USRA, (4) NASA/MSFC, (5) METU



To continuously monitor the full sky for accreting X-ray pulsars with spin frequencies in the 1 mHz to 2 Hz range.

This monitoring system has two components:

- 1) daily blind search for pulsed sources, and
- 2) **monitoring known sources, e.g. 4U 1626-67**



4U 1626-67

The Fermi/Gamma-ray Burst Monitor (GBM)



GBM :

12 Sodium Iodide (NaI) and
2 Bismuth Germanate (BGO)
scintillation detectors

Energy range:

NaI det: ~8 keV to 1 MeV

BGO det: 200 keV to 40MeV.

Observations:

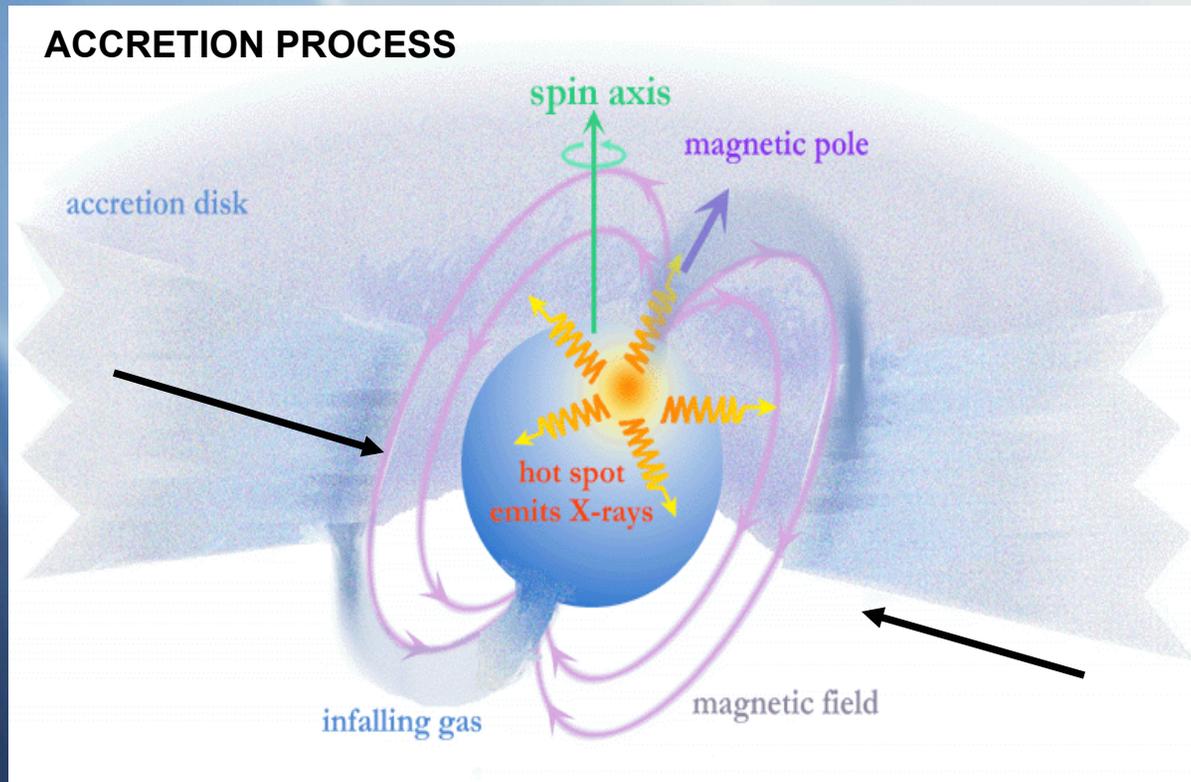
-(GBM) NaI detectors CTIME data
(0.256 s time bins, and 8 energy
channels).

- Our analysis: **channels 1** (11.7-26.8 keV)
and **2** (26.8-50.3 keV).

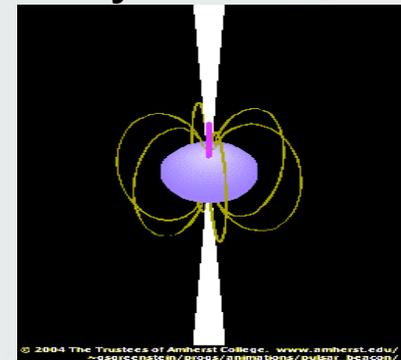


Accreting X-ray pulsars

Introduction



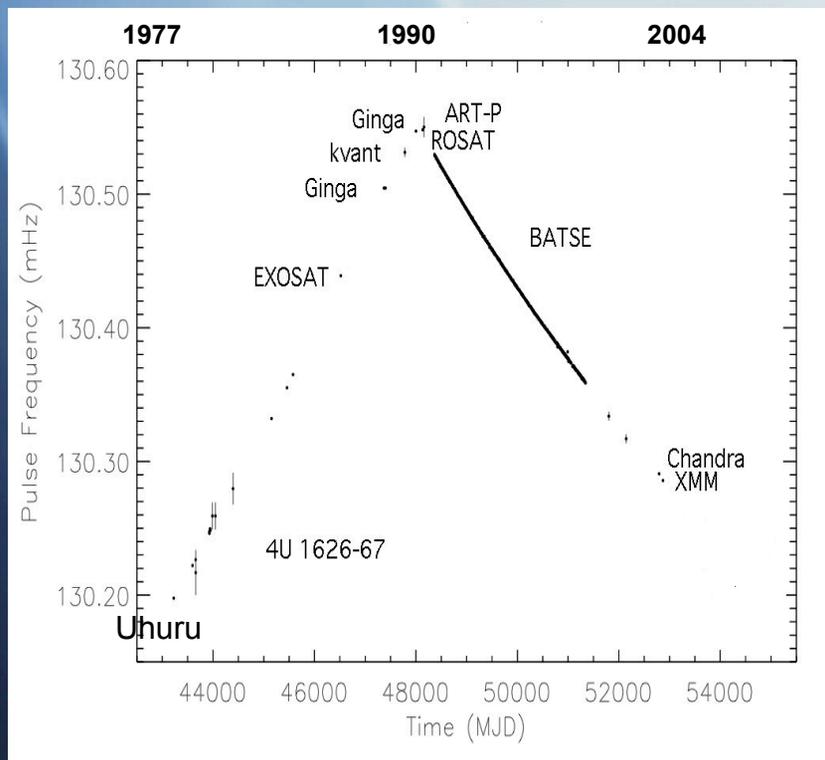
X-ray Pulsations



2009 Fermi Symposium

2-5 November Washington

What do we know about 4U 1626-67?

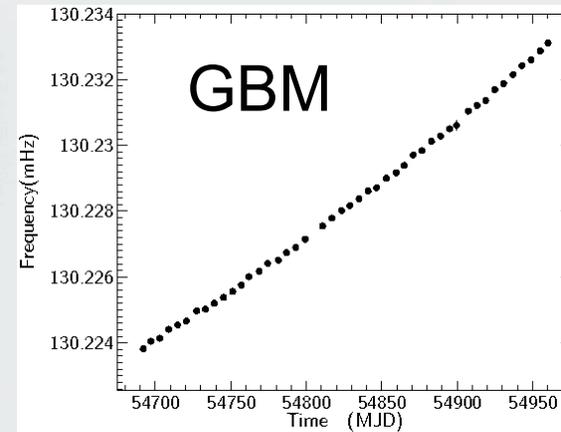
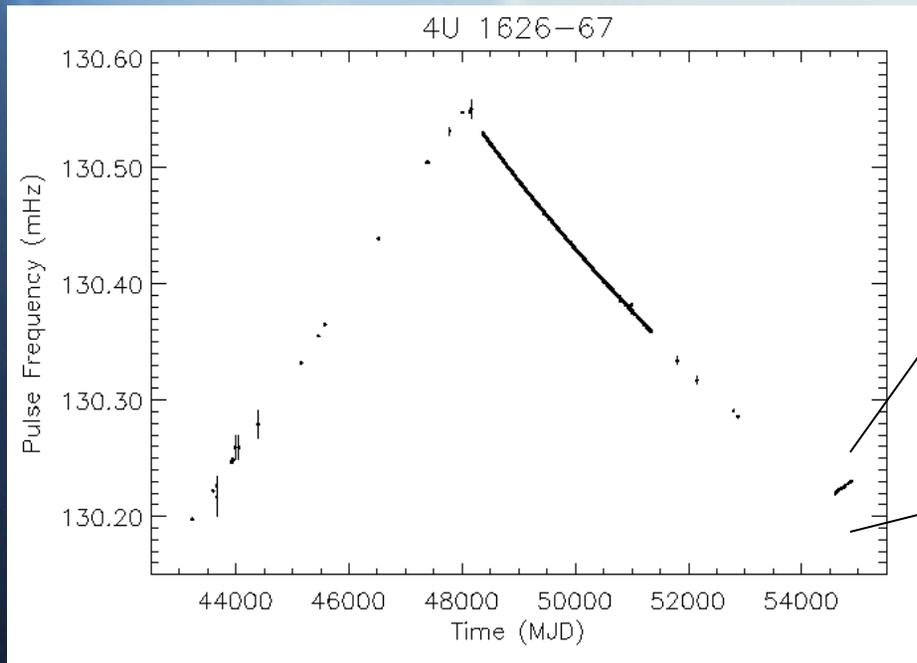


- . LMXRB
- . $P_{\text{pulse}} = 7.66 \text{ s}$
- . Ultracompact 42 min orbit
- . Optical counterpart: KZ TrA , $V \sim 17.5$
(strong UV excess and high optical pulse fraction)
- . 48 mHz quasi-periodic oscillation (QPO)
- . $\sim 37 \text{ keV}$ absorption cyclotron feature
- . $B = (2.4-6.3) \times 10^{12} \text{ G}$
- . Distance 5-13 kpc

4U 1626-67

Timing results

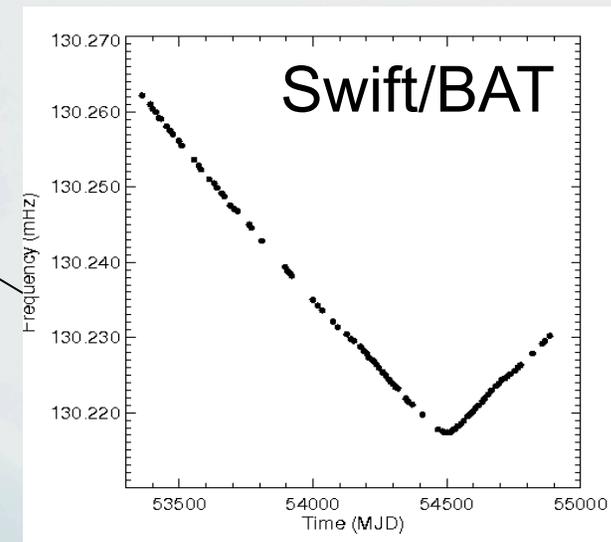
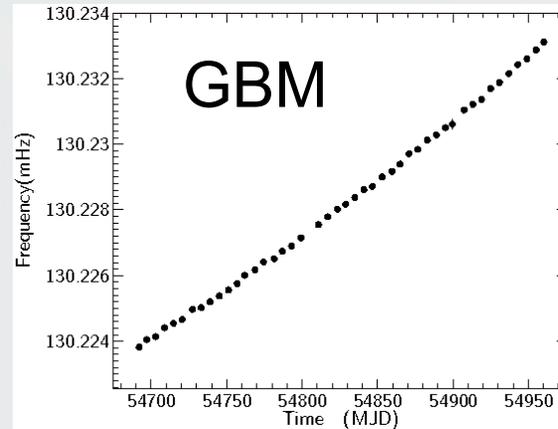
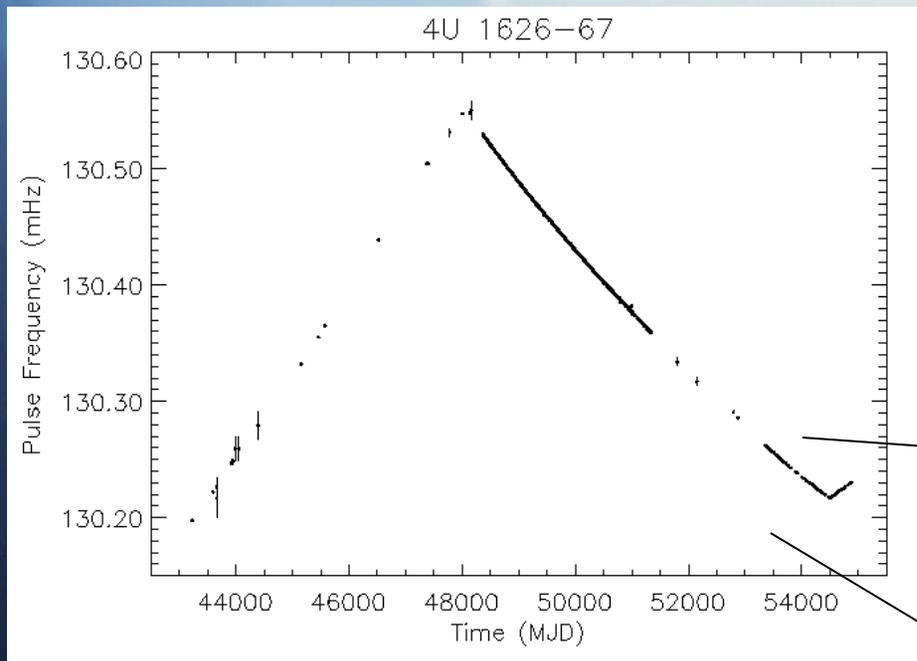
NEW TORQUE REVERSAL AND SPIN-UP OF THE ACCRETING
X-RAY PULSAR 4U 1626-67
(submitted to ApJ; Atel #2099)



4U 1626-67

Timing results

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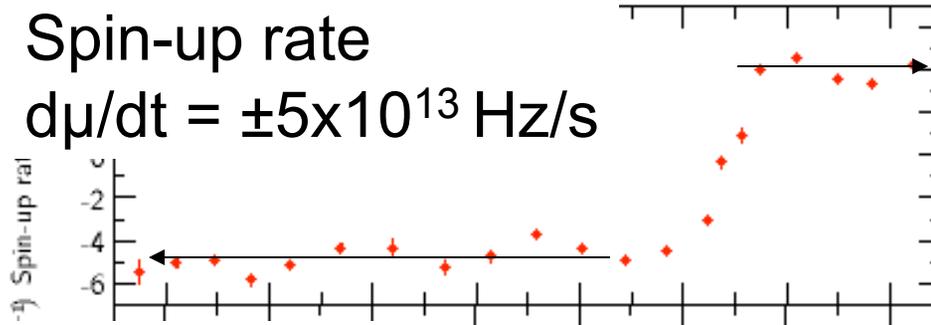
**Torque reversal centered in 2008 Feb 4
lasting ~150 days**



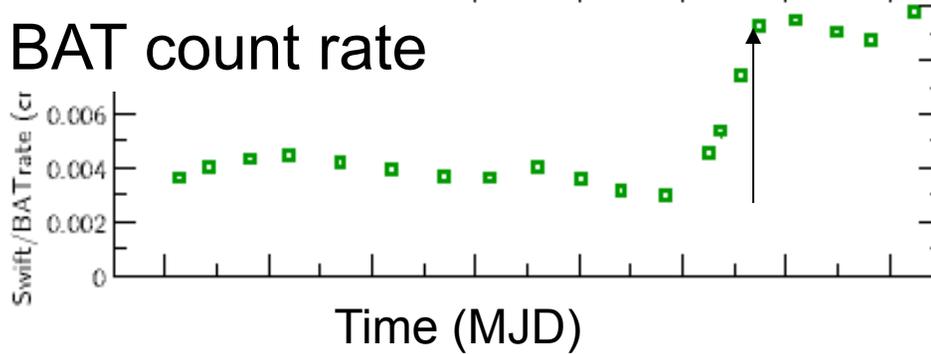
4U 1626-67

Timing results

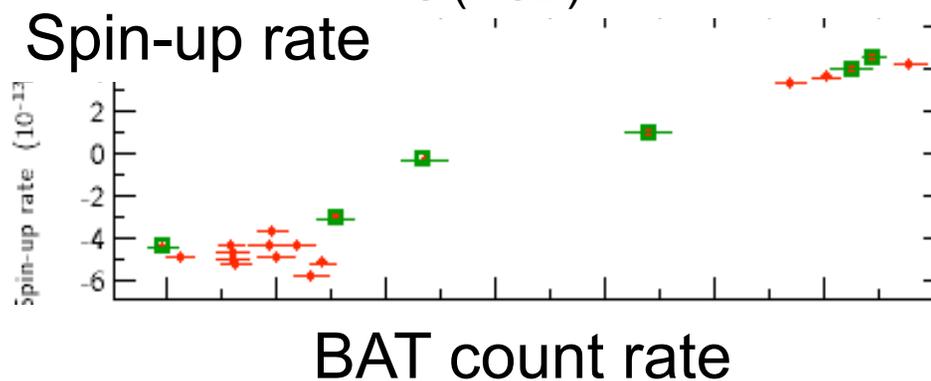
Spin-up rate
 $d\mu/dt = \pm 5 \times 10^{13} \text{ Hz/s}$



BAT count rate



Spin-up rate

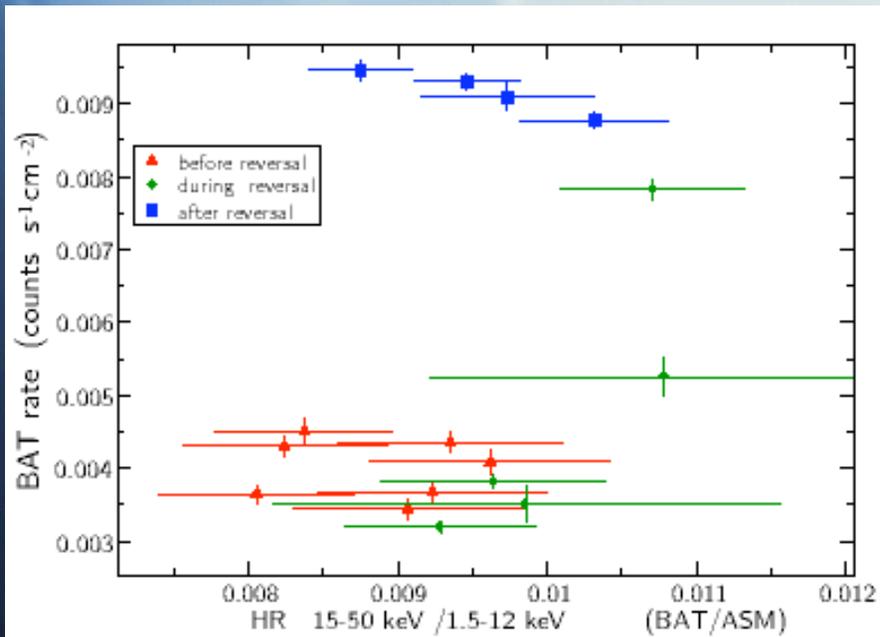


Almost identical spin up rates before and after the reversal

Count rate increment a factor of 2.5

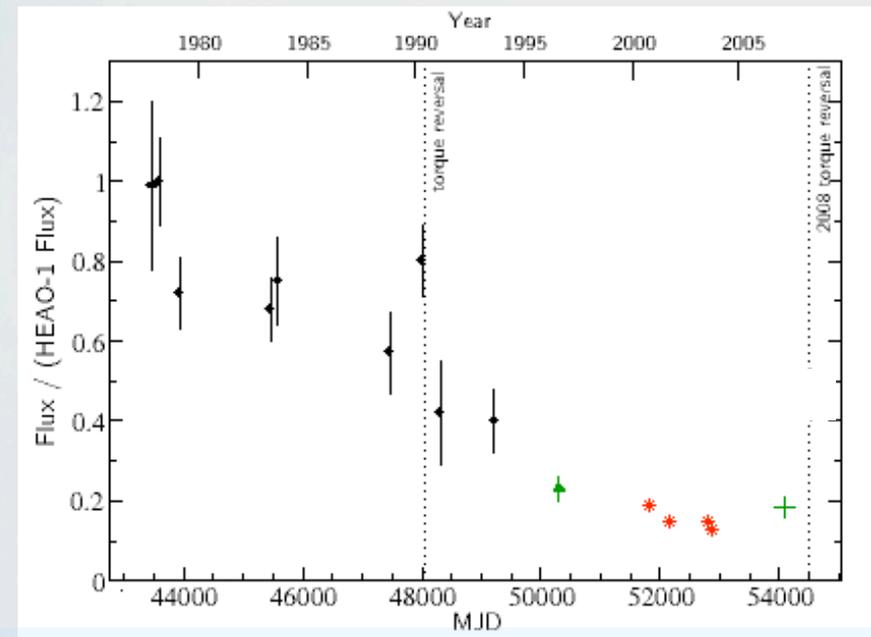
Strong torque-luminosity correlation, only during the torque reversal (green squares).

HR-intensity diagram



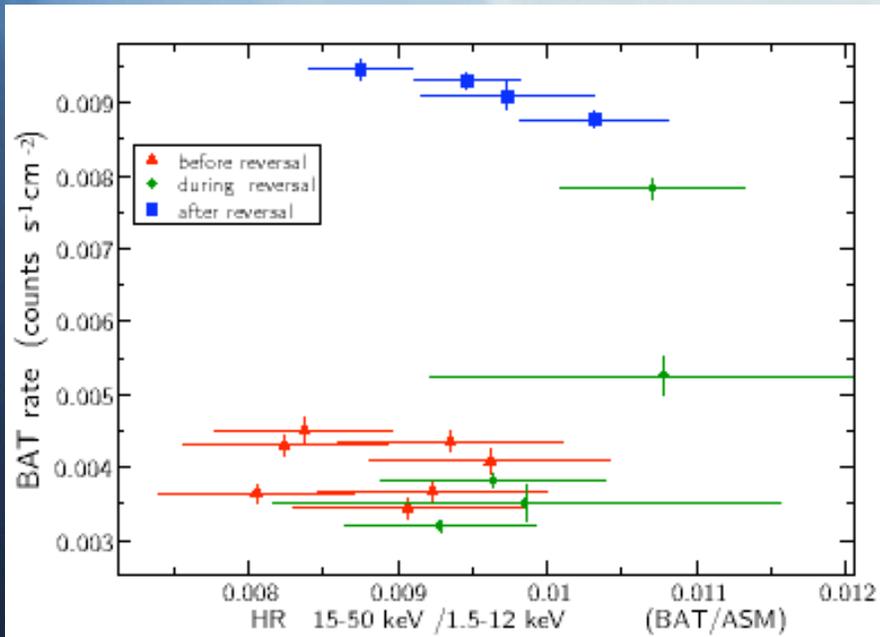
Spectral transition from hard to soft during the torque reversal

Long-term X-ray flux history (relative to HEAO 1)



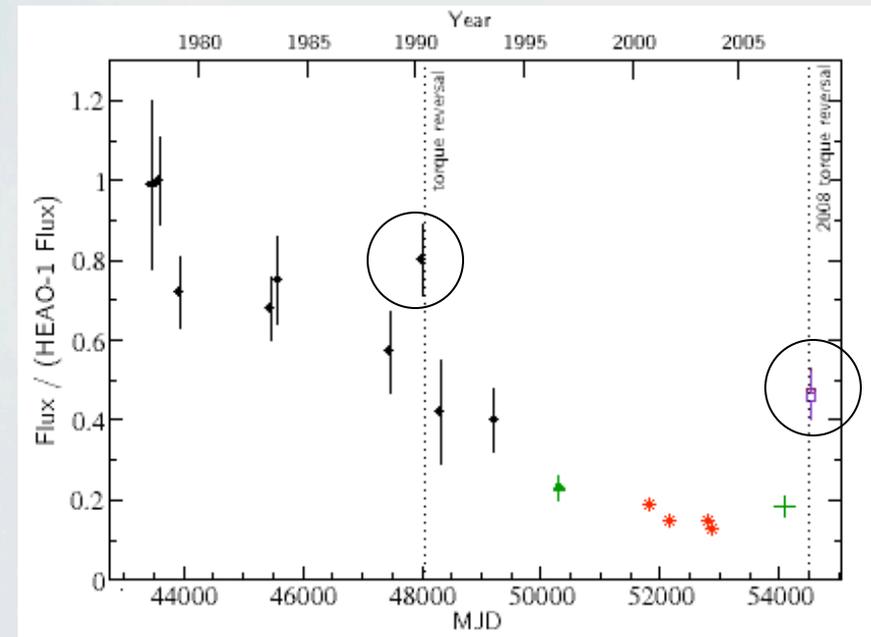
- Same physical mechanism operating in 1990 and 2008 reversals? → same flux values for both transitions

HR-intensity diagram



Spectral transition from hard to soft during the torque reversal

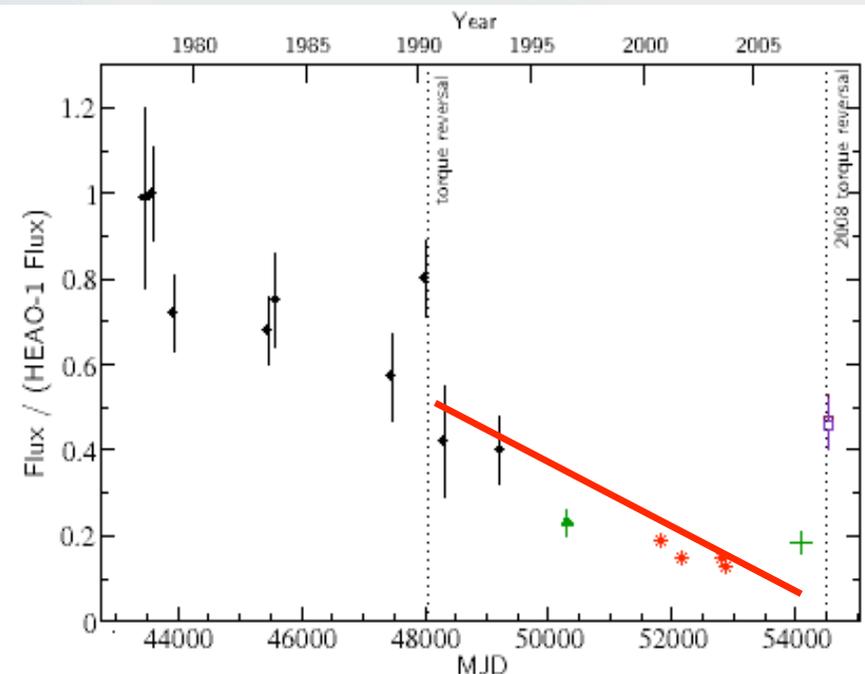
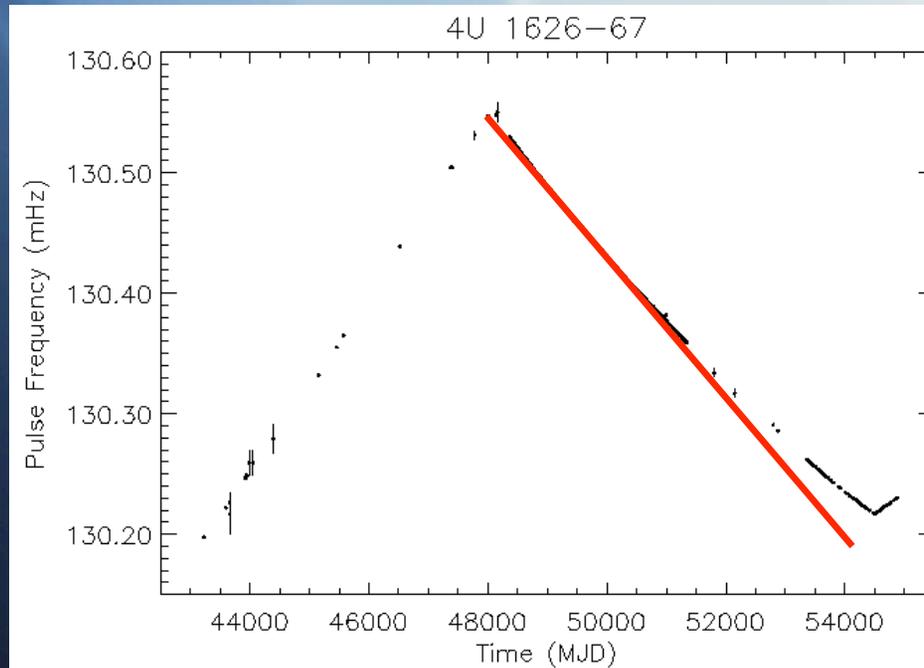
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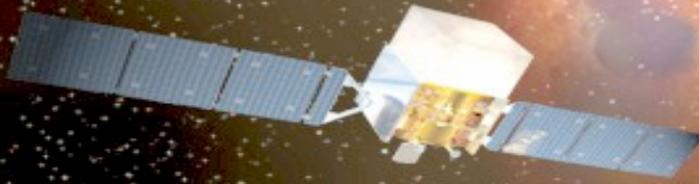
- Different flux values → ?
- Models fail to reproduce these observations

results

During the spin down period there appears to be a torque-luminosity ANTIcorrelation

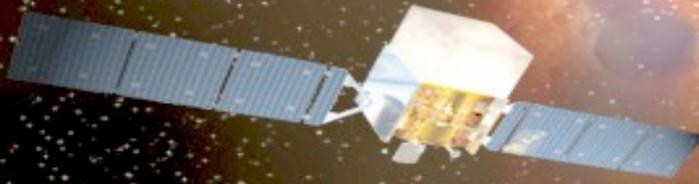


**The NS spins faster as it approaches torque reversal,
BUT the flux decreases !!**



Summary and conclusions

- **After about 18 years of steadily spinning down 4U1626-67 experienced a new torque reversal.**
- **It becomes difficult to reconcile theoretical models with these recent observations:**
 - 1) The spin-up and spin-down torques were again almost identical before and after the transition.
 - 2) It lasted ~150 days (centered on 2008 Feb 4).
 - 3) During the spin down period (from 1990 to 2008), the spin-up rate was increasing while the flux decreased.
 - 4) Only during the reversal we found a strong torque-luminosity correlation.
 - 5) The X-ray flux values from the 1990 June and the 2008 Feb torque reversals are different.
 - 6) The spectrum during the transition is the hardest.



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- After about 18 years of steadily spinning down 4U1626-67 experienced a new torque reversal.
- It becomes difficult to reconcile theoretical models with these recent observations:
 - 1) The spin-up and spin-down torques were again almost identical before and after the transition.
 - 2) It lasted ~150 days (centered on 2008 Feb 4).
 - 3) During the spin down period (from 1990 to 2008), the spin-up rate was increasing while the flux decreased.
 - 4) Only during the reversal we found a strong correlation torque-luminosity.
 - 5) The X-ray flux values from the 1990 June and the 2008 Feb torque reversals are different.
 - 6) The spectrum is harder during the torque transition than before or after.

Today the GBM pulsar project has detected 17 accreting X-ray pulsars and is currently monitoring historical transients, including 4U 1626-67 (more info: Mark Finger's talk).